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ABSTRACT

Epistemological perspectives are the ways students interpret or make meaning of their educational experience. Research has stressed the need to develop strategies to counter traditional mathematics pedagogy and epistemology because they have alienated many girls and women. An integrated framework of two cognitive developmental models describe these ways that women have of viewing reality: (1) Silence produces a sense of feeling dumb; (2) Absolute Knowledge replicates the knowledge of authorities; (3) Subjective Knowers have a need for personal understanding; (4) Transitional Knowers accept multiple perspectives; (5) Independent Knowers value diverse methods; (6) Procedural Knowers use systematic analysis; and (7) Contextual and Constructed Knowers have an authentic voice. Each one of these relates to a particular role of the teacher and peers. Interviews with adult full-time women's-only technical and further education mathematics students were conducted after three weeks and at the end of the class and show how different experiences of peers and the teacher in the same class are viewed through an epistemological lens. One student came into the class with a Silent perspective, but by the end of class was a Subjective Knower. The second student was an Absolute Knower but left the class having shifted towards being a Transitional Knower. (Contains 19 references.) (SLR)

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Tracking Ways of Coming to Know With the Shifting Role of Teachers and Peers: An Adult Mathematics Classroom

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Introduction

Epistemological perspectives are the ways students interpret or make meaning of their educational experiences as a result of their assumptions about the nature, limits, and certainty of knowledge (Perry, 1970). Collectively these perspectives form ways of knowing (Kitchener, 1983). Recent research initiatives in the area of women and mathematics stress the need to develop strategies to counter traditional mathematics pedagogy and epistemology which is proposed to have alienated many girls and women by not appreciating or validating their ways of coming to know (Becker, 1996; Burton, 1995, 1996; Jungwirth, 1993; Roger & Kaiser, 1995). How students come to know mathematics, as well as the nature of mathematics itself, is particularly pertinent for students who are traditionally under-represented in mathematics.

The perception that mathematics is absolute is an epistemological perspective and is common among women returning to study mathematics where it is associated with a perceived need for procedural learning or rule following (Beesey, 1995). In this context the teaching philosophy proposed to provide the opportunity for success incorporates the women's common-sense knowledge, draws upon and values their own experiences, focuses on practical applicability, and promotes a collaborative classroom environment (Feil, 1995; Helme, 1995; Isaacson, 1990). Research on whether the women's epistemological assumptions about mathematical knowledge change over the duration of such courses to promote more complex ways of knowing is in its infancy (see Taylor, 1995). Becker (1996) suggested the theories of Belenky et al. (1986) and Baxter Magolda (1992) as possible guides in future research on gender and mathematics.

Theoretical Framework

Belenky et al. (1986) and Baxter Magolda (1992) re-examined the cognitive developmental theory of Perry (1970), considered by Foley (2000) to be one of the most interesting theories for adult educators. Perry (1970) proposed a schema of how male¹ university students shift from seeing knowledge as something that is handed down to them from authorities to seeing knowledge as relative (everyone has the right to their own opinions) to seeing that knowledge is constructed by people in particular social contexts in accordance with particular values. The models of Belenky et al. (based on women's experiences from a broad range of socio-economic backgrounds) and Baxter Magolda (based on both men and women's experiences in a university context) broadly overlap with the schema proposed by Perry (1970), but significant divergence was noted. Belenky et al found that many women experienced greater obstacles in their intellectual development, that they had more distant relationship to authority, and along with Baxter Magolda (1992), also noted how women are more likely to come to know through inter-personal relationships.

Using a grounded theory approach Belenky et al. (1986) proposed five perspectives from which women view reality and draw conclusions about truth, knowledge, and authority: *Silence*; *Receiver*; *Subjective*; *Procedural*; and *Constructed* (see Table 1). The "Silent" perspective is particularly pertinent for women returning to study mathematics due to the anxiety many have with the learning of mathematics as a consequence of poor experiences at school. The "Receiver" perspective most closely aligns with the emphasis on rule based learning. A "Subjective" perspective, a focus on relying on personal experiences to create meaning, may also represent a further hurdle to overcome to allow for the acceptance of mathematical knowledge derived by external authorities to be viewed with legitimacy. The term "Procedural" knower is unfortunate in the context of learning mathematics as it is usually associated with rule following rather than the systematic reasoning that Belenky et al. convey. Two voices emerged for the Procedural knower, Connected and Separate knowing. These voices appear to be the precursors to Baxter Magolda's gender-related reasoning patterns discussed

¹ Perry (1970) did interview some women but his schema was based entirely on men's experiences.

below and in Table 1. Belenky et al. were reticent to propose a hierarchical schema and suggested future research would shed light on this aspect of their work.

Baxter Magolda (1992) identified four qualitatively different ways of coming to know that she proposed were stage-like: *Absolute*; *Transitional*; *Independent*; and *Contextual* (see Table 1 for a description). While Transitional knowers are struggling to move away from an Absolute orientation, to come to terms with knowledge being inherently uncertain and socially constructed, thinking for oneself is the core element of the Independent knower. Contextual knowers extend this position "to thinking for oneself within the context of knowledge generated by others" (p.168). While all four ways of knowing were evident for both men and women, gender-related reasoning patterns were identified (see Table 1). Women are proposed to more likely develop intellectually via the receiving, interpersonal, and inter-individual reasoning patterns while men are proposed to more likely develop intellectually through the mastering, impersonal, and individual reasoning patterns. The integration of the models proposed by Belenky et al. and Baxter Magolda are provided in Table 1 but also see Brew (1999).

The positioning of the subjective knower described by Belenky et al. with respect to Baxter Magolda is difficult to integrate having elements of absolute and transitional knowing but different all the same because of the reliance on relying on personal knowledge rather than knowledge derived from authorities to determine what is truth. As over half of the women interviewed by Belenky et al. conveyed this orientation and a shift into this perspective often preceded women making the decision to return to study, it remains an important perspective in the context of adult further education.

Baxter Magolda's model was chosen as the starting framework for two main reasons. First because she described how students shift in their epistemological perspectives with respect to five domains of learning: the role of the learner, peers, the teacher, assessment, and perception of knowledge. These domains provide a useful structure for a formal learning setting. Second, it was important to be open to hearing diverse voices, the gender-related, not gender-dictated reasoning patterns. The five perspectives of Belenky et al. were then integrated as feasibly as possible.

Here I focus on two key learning domains of Baxter Magolda, the role of the teacher and peers, to explore whether the integrated framework provides a useful lens to consider women's ways of coming to know mathematics. Ultimately the aim is to provide a framework to guide the teaching of mathematics where the absoluteness of mathematical knowledge can be challenged while at the same time holding on to the objectivity, the precision, and the accuracy that such knowledge can provide.

Methodology

Data were collected from students enrolled in a full-time women's only Technical and Further Education (TAFE) science course where mathematics was a significant component. The course was developed for early school-leavers to provide them with the option of entering into non-traditional areas of further study. Here there was a commitment to collaborative group work as the teacher believed there was immense value for learners to verbalise their own understanding and hear others clarify their reasoning.

Initial interviews with participants occurred at the end of their second term and this was after three weeks of attendance at classes. Follow-up interviews occurred at the end of the course and many of these were by telephone. Observation of classes continued on a regular basis. Interviews explored the students' perspectives on mathematical learning with respect to the five domains of learning. Their reasons for returning to study along with past school experiences were also gathered. I focus on two case studies using interview and observational data to illustrate different epistemological perspectives with respect to the role of the teacher and peers.

Table 1: Summary of the Integrated Epistemological Models of Belenky et al. (1986) and Baxter Magolda (1992)

Table 1: Dimensions of the 'Absolute Knower' (Belenky et al., 1986)							
	Silence (Belenky et al.)	Absolute Knower (Belenky et al. & Baxter Magolda)	Subjective Knower (Belenky et al.)	Transitional knower (Baxter Magolda)	Independent knower (Baxter Magolda)	Procedural knower (Belenky et al.)	Contextual (Baxter Magolda) & Constructed knower (Belenky et al.)
General description	Sense of feeling dumb and stupid	Dualistic thinking. Replicate knowledge of authorities. Confused by ambiguity	The mathematics has to be personally owned or will be rejected	Some knowledge is uncertain where multiple perspectives are legitimate	Absolute perspective replaced by the valuing of diverse methods & explanations. Judgment as to which methods are more valid is rare.	Some truths are truer than others. Systematic analysis. Elements of Independent knowing	An authentic voice. Ambiguities & complexities in mathematical knowledge authentic. Indicative of the use of mathematics in social contexts
Role of the teacher	Passive, reactive and dependent on external authority for direction and truth	Receiver reasoning pattern Provide a relaxed environment. Minimal interaction expected.	To make the mathematics relevant.	Inter-personal reasoning pattern Encourage peer interaction, the verbalising of the mathematics	Inter-individual reasoning pattern & Connected knowing To provide an environment in which different approaches to solving mathematical problems are valued		The gender-related reasoning patterns of the Independent knower & the two Procedural voices proposed to converge
		Mastery reasoning pattern Strong identification. Expectation to be quizzed.		Individual reasoning pattern & Separate knowing To provide an environment in which their own and others' approaches to solving mathematical problems can be debated			
Role of peers	An inability to find meaning in the words of others or learn from others' experience	Receiver reasoning pattern Social. To create relaxed atmosphere and to ask questions to relieve pressure	To support making the mathematics real, relevant to their everyday lives	Inter-personal reasoning pattern Openness to peers' knowledge as this provides different ways of understanding the mathematics	Inter-individual reasoning pattern Greater valuing of peers' reasoning. Assists understanding their own.	Connected knowing Seek to understand how others develop different perspectives from their own	
		Mastery reasoning pattern Quiz peers to aid each others' mastery of knowledge		Impersonal reasoning pattern Peer interaction to establish credibility	Individual reasoning pattern Seek debate with peers to support their own mathematical understanding	Separate knowing Play devil's advocate, seek logical contradictions in other's arguments	

Case Study 1

Cheryl was 22, lived with the father of their small child, and wanted to be a nurse. Cheryl completed grade 12 but described how she would feel physically sick before going to a maths class. In interview 1 Cheryl conveyed a subjectivist perspective in coming to know mathematics through her recognition that she discards knowledge that makes no personal sense. The anxiety that she struggles with also resonates with the silent perspective in terms of an inner voice telling her she is incapable of learning mathematics.

Unless something makes complete total sense to me I refuse to acknowledge it, my brain just discards it. ... I flash back, "see you're stupid, you don't get it, you were never meant to do maths."

Regarding the role of the teacher, her reflections also conveyed a mastery reasoning pattern through enjoying being visible in class and being competitive with her peers. As this reasoning pattern was more evident among males in Baxter Magolda's sample it was perhaps significant that Cheryl wished there were males in the class.

Role of the Teacher

She put the sheet in front of us and I was thinking I won't say anything, no one else has said anything, they must just get it. ... I was the only one left in the room and I just cried, [laugh], and the teacher goes "what is wrong?" ... She said "just tell me next time" and went through it. Ever since then she always looks at me and gives me a nod, and I'm like, "yeah that's fine," or I will frown at her. And she will come over and go through it. ... fractions was my biggest block. ... She gave us a full circle, half, thirds, ... up to 16ths, and we sat for a week with these ... at the end I am the best in the class.

Role of Peers

I am cooperative ... but only if you are cooperative with me. ... I find I am very loud, and I know I have pissed people off, but at the same time I let other people talk. ... Nancy and Kate ... they just race ahead of me, ... what I hate is when they don't get something and I do, they expect me to sit and explain it to them. ... Maybe if there were half a class of guys and half a class of women it would balance out.

In interview 2 Cheryl spoke about becoming more focused on her own mathematical learning as if this was at the expense of the learning of her peers. As peers were still conveyed as playing an important role in her learning where their alternative ways of thinking were valued, this would suggest a perspective consistent with the impersonal reasoning pattern of the Transitional knower. Further evidence of the impersonal reasoning pattern emerged later in the interview in relation to the role of peers in terms of them providing the opportunity through engagement to establish her mathematical credibility.

In the end I was like I am doing this for myself, I am not doing this for you. ... I was still very reliant on Nancy and Kate, like "am I doing this right?" ... Nancy and I were very much in common because I would look at things one way and she would look at things in a completely different way, sometimes I was right, sometimes she was right.

I: You did get into a lot of explaining to Nancy.

Oh I loved it! [laugh].

I: Did that help you?

Yeah! It just reinforced that I do know this, and I could prove it because look here is the answer.

When I followed up her idea of wanting men in the class, her response suggests that they could contribute to her learning in a different way from women, albeit in terms of their more impersonal approach to learning.

Most men I know tend to ... this is a generalisation ... this is how you've got to do it ... they say this is the rule, follow this and you are done. Whereas women need to know where did that rule come from?

I: You like that way of thinking?

I can accept it more now and understand it, now that I know these rules just don't come out of thin air and actually have meaning. ... Whereas before ... I would have looked at the rule and gone I don't know how to do that [laugh]. ... But now I know why they are the rule, ... like if we went to uni and they decided to teach that way I wouldn't have a problem with it.

Case Study 2

Pauline was 39, had four adult children and left school in grade 11. She was different from Cheryl, being at a different stage of her life, and had also enjoyed mathematics at school. From observations she was very quick to solve work sets. In interview 1 Pauline conveyed that she appreciated the encouragement of student interaction and that the teacher did not present herself as the ultimate authority. Nancy also gained an appreciation of her peer's alternative methods. Overall her comments are consistent with the inter-personal reasoning pattern of the Transitional knower who is beginning to legitimize peers' knowledge and view the role of the teacher as a facilitator, rather than to impart knowledge of authorities.

Role of the Teacher

You really do feel you are on a level footing, ... if you don't understand something you can ask them to clarify it without making you feel stupid. ... The teachers aren't up there "we know it all and you know nothing." The teachers are prepared to consider what the students have to say.

I: Were you a bit nervous initially to speak out?

Yeah ... I sat back in the corner and slowly integrated.

Role of Peers

We are not there to compete, you are there to help each other. ... Like with Fran, I was showing her the way I was doing it, and she was sort of not really understanding it. But then she did it another way and said "well is this way wrong?" I said "no, it is just different" ... She did it her way and still got the same answer. I was able to let her know, it is not always just one way to do something, there is more than one way, as long as you get the right result.

In interview 2 by telephone, Pauline spoke again about this specific interaction with Fran. Here evidence emerged of her applying her new epistemological outlook on mathematical learning to her every-day life. That is, Pauline had begun to recognise the value of applying ideas learnt within a collaborative mathematics classroom to areas of her life that were quite distinct from the learning of mathematics.

I think I mentioned last time with Fran. ... I tried to explain the way I was doing it, and then she said "well this is the way I started to do it is it wrong?" And I looked at it and said "no, it is not wrong it is just different from my way."

I: Were there any other interactions like that?

Not that I can think of, that one was sort of an important one for me. I don't know why.

I: It was just a really important one?

Yeah I think it was good for me at that point of time because there were a few things going on ... that I wasn't getting things right.

I: What was that?

Oh personal stuff.

I: So you related it to that. Did it help you?

It helped me sort of get on and put a couple of things behind me.

I: Thinking that two people could be right?

Yeah. So that is why it stuck in my mind.

I: So that was in terms of your personal relationships but you connected it to your experience of learning mathematics?

Yeah.

I: If you had seen maths in terms of there being only one right way, would that have meant you would have struggled with your personal situation?

Yeah. I AM SURE OF IT. [laugh]

I: You were sure you were right or you were wrong? [laughing]

In that instance I thought I was right, and that was it! [laughter]

I: You realised there was another perspective?

Yeah [giggling]

Discussion

Using the two case studies I have endeavored to show how different experiences of peers and the teacher in the same adult mathematics classroom might be viewed through an epistemological lens. It is worth conjecturing that if students' epistemological perspectives are to shift in such a course then they do so quite dramatically within the first few months as long as the learning environment is conducive. Baxter Magolda discusses how Absolute knowers "do not begin to view themselves as knowers until the learning environment implies or states directly that they have something of value to say" (p.273). In this classroom the teacher was vigilant in her efforts to validate the students' ideas and encouraged them to examine each other's methods and this would appear to have set the context. Perry (1970) noted that epistemological shifts occurred suddenly rather than gradually for his interviewees. Women who are early school-leavers, who have made the commitment to return to study, are already in a transition phase with respect to thinking about their own learning and are therefore probably quite open to accepting alternative modes of teaching and this was confirmed by the teacher.

Case study 1 is a student who shifted enormously in her attitude towards mathematics—who came to the course with what can be described as a silence perspective, a belief that she was incapable of learning mathematics. She also expressed a view of coming to know mathematics that could be linked to subjective knowing—a strong sense of needing to own and understand the knowledge personally, consistent with the notion of personal agency or authorship described by Burton (1999). Baxter Magolda's framework was then helpful in viewing subtle shifts in relation to the role of the teacher and peers in her mathematical learning for the notions of connected and separate knowing are too advanced epistemologically. Instead the mastering and impersonal reasoning patterns, precursors to separate knowing, better described Cheryl's predominate way of coming to develop her mathematical voice.

Case study 2 is a student who came into the course feeling very comfortable with mathematics. Her reflections suggest that she came into the course as an absolute knower, who perceived that mathematics was about being right and wrong. This notion was challenged by peer interaction and interestingly her apparent epistemological shift with respect to mathematics flowed into her personal life. Goldberger (1996) states that what determines a person's shift in epistemological perspective may be contextual rather than developmental. For Pauline, the notion of a developmental rather than a contextual shift is more evident.

The types of student perspectives conveyed here are not new and other lenses could be used to describe them. Through overlaying an epistemological model the notion of stages of mathematical development is proposed in the context of women returning to study in the further education sector. Such a model, I suggest, allows for the noting of subtle shifts in women's reasoning over time and an epistemological perspective on why difficulty can be experienced by students when asked to engage collaboratively with peers. A pathway towards encouraging more complex ways of knowing mathematics may also be made clearer.

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